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Stable Cementless Wrist Prosthesis (SCW prosthesis)

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Abstract

A new wrist prosthesis (SCW prosthesis) is an unconstrained wrist prosthesis which consists of two components. They are made of alumina ceramics and high density polyethylene. It is designed to provide good range of motion, especially full range of extension. A wide contact area of the articulation gives good stability. As the stem and pegs of the prosthesis are made of ceramics, they incorporate well to the bone without cementing. This prosthesis was clinically used in two wrists of two patients. Both patients are postoperatively satisfied with the stable painless wrist.

Introduction

Total joint replacement with an artificial endoprosthesis is now commonly used to restore function of a destroyed joint due to osteoarthritis, rheumatoid arthritis and other pathologic conditions. Total wrist replacement was first reported by *Meuli* in 1973[7]. Since then, many investigators attempted to restore the function of the hand by total wrist replacement.

The human wrist joint consists of eight carpal bones and has very complicated movement. The wrist joint requires good motions, stability and power. Therefore, it is quite difficult to restore normal function of the wrist joint with an artificial prosthesis.

Here is reported a new wrist prosthesis, named "Stable Cementless Wrist Prosthesis (SCW prosthesis). It is a wrist endoprosthesis which is designed to provide mobility as well as stability of the wrist and does not require bone cement for fixation. This prosthesis was clinically used for two wrists of two cases : one of osteoarthritis and the other of rheumatoid arthritis.

Structure of the prosthesis

This wrist prosthesis is composed of two components : the prximal and distal component.

Key Words: Wrist Prosthesis, Implant, Arthroplasty, Wrist, Joint replacement, Ceramics.
索引語：人工手関節，挿入物，関節形成術，手関節，関節置換術，セラミックス.
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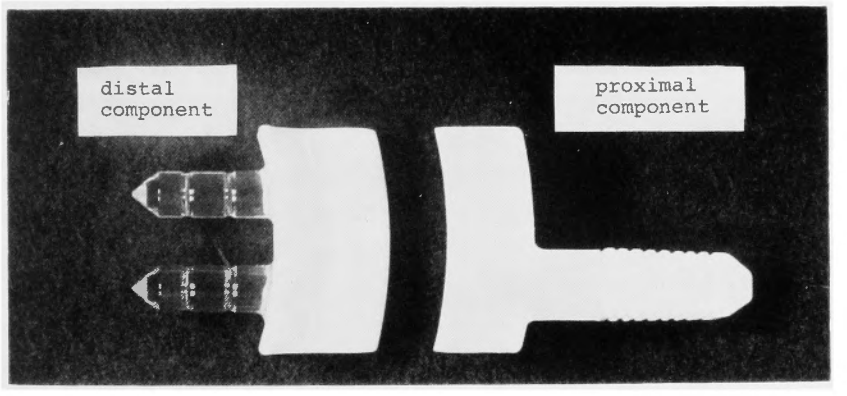
The proximal component consists of a quadrangular stem and a wide rectangular articular portion. The stem is made of polycristal alumina ceramics. Since the stem is shaped quadrangular and a few transverse grooves were inscribed on the surfaces, it can be incorporated well to the bone without cement. The articular portion of the proximal component is made of high density polyethylene. Its articular surface has two different concave curvatures: a curve with a larger radius is on the radio-ulnar plane and a smaller radius on the anteroposterior plane. There is a protrusion from the distal palmar aspect of the articular portion which serves as a shelf to hold the articular portion of the distal component. The distal component consists of a curved cylindric articular portion and two pegs. The articular portion of the distal component is made of polycristal alumina ceramics which has two different convex curvatures fitting to the concave articular surface of the proximal component. Two pegs are made of monocristal alumina ceramics which can be incorporate to the metacarpal bones without cement (Fig. 1).

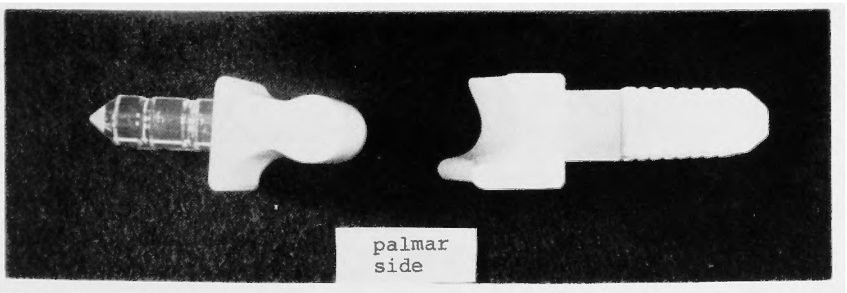
Clinical Cases

This prosthesis has been applied to two wrist joints of two patients.

Case 1 was 38 year old male carpenter. The patient first experienced pain in the right wrist joint during his work in January 1978. He consulted with a doctor in his neighbor who injected



a. dorsal view



b. side view

Fig. 1. Stable Cementless Wrist Prosthesis
The proximal component consists of a quadranqular ceramic stem and a HDP articular portion. The distal component consists of a ceramic articular portion and two pegs. The transparent pegs are made of monocristal alumina ceramics.

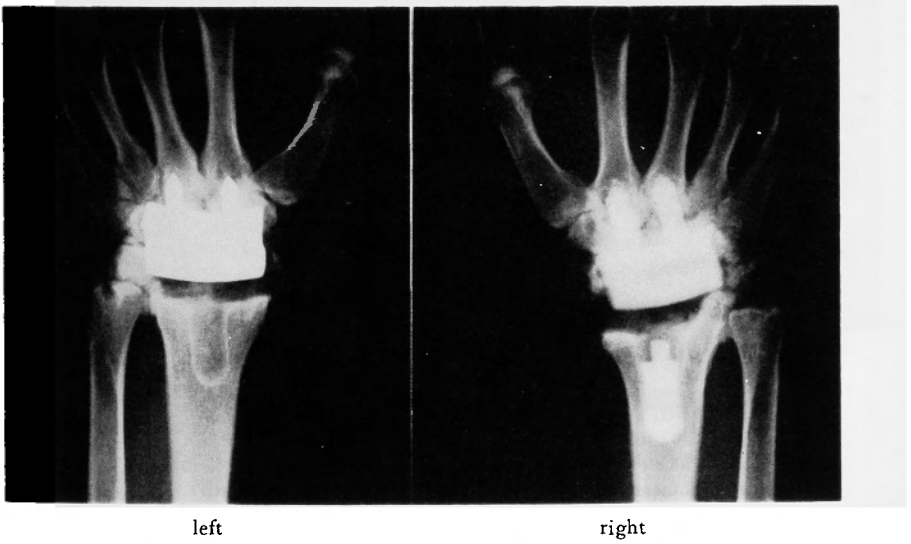
left right

Fig. 2. A preoperative radiograph showing severe osteoarthritis of the radiocarpal and intercarpal joints of both hands.

steroid into the wrist joint resulting in only temporal relief. Although the wrist was treated by physiotherapy and multiple steroid injections, pain could not be relieved but gradually aggravated. As being unable to use his right hand, he had to work with the left hand by the summer of that year. Then pain developed in the left wrist. In spite of physiotherapy and multiple injections of steroid into the wrist joint, pain and limited motions of both wrists progressed to such extent that he could not work anymore as a carpenter. He first visited our outpatient clinic on April 22, 1979 to seek treatment for the wrist joints. X-ray film revealed severe osteoarthrites of both wrist joints. Degenerative change involved not only the radiocarpal joint but also the intercarpal joint (Fig. 2). He was admitted to the hospital for surgery. Physical examination at the time of admission revealed a healthy normal adult except for the wrist joints. Both wrists were diffusely swollen and tender. The wrist joints had little motions and were very painful. The patient underwent the first operation on July 2, 1982, when a total prosthetic replacement was performed on the left wrist joint. The prosthesis used at that time was almost the same as that reported here, but was made of metal and high density polyethylene. The postoperative course was unevenful. The left wrist became stable and painless. The patient was pleased with the postoperative result and desired a surgery for the right wrist. A total prosthetic relacement for the right wrist using the SCW prosthesis was performed on July 12, 1983. A S-shaped skin incision was made on the dorsum of the right wrist. Two subcutaneous large veins were cut, but not ligated to be anastonosted at the later stage of the operation. By retracting extensor tendons, the dorsal capsule of the wrist joint was exposed. The dorsal capsule was incised and elevated as a flap carring distal pedicle. The distal end of the radius and the almost entire carpus were exposed. After dislocation of the wrist joint, the distal end of the radius was cut transversely straight, leaving only the thin palmar cortex. A quadranqular hole was made from the distal surface into the radius to accommodate the stem of the proximal component. The proximal protion of the carpus was partially removed

in such a way that the distal component can be placed there. Namely, almost all proximal carpal bones except the pisiform and the proximal part of the distal carpal row were removed. Two drill holes were made from the proximal surface of the remaining distal carpals into the second and third metacarpal base to accommodate two pegs of the distal compoenet. The palmar joint capsule was preserved to ensure stability of the joint. The quadrangular stem of the proximal component was snugly inserted into a hole made in the radius, and the two pegs of the distal component were introduced into the second and third metacarpal base through the remaining distal carpal bones. They were well fixed to the bones without cementing. After reduction of the wrist joint, the dorsal capsule was repaired. And the distal portion of the extensor retinaculum was placed just over the dorsal joint capsule and under the extensor tendons. The proximal portion of the extensor retinaculum was placed over the extensor tendons and repaired. Two subcutaneous veins, which were cut previously, were repaired under a microscope to promote venous drainage and to minimize postoperative edema. The subcutaneous tissue and the skin were closed by layer. After the wound was covered with sterile dressings, the wrist was immobilized with a plaster cast. Postoperative course was uneventful, though a small portion of the dorsal skin fell into sloughing. Active exercise of the wrist was postponed until 5 weeks after the operation due to the slough. Two and a half year after the operation, the ranges of motion of the right wrist are dorsiflextion 30°, palmar flexion 10°, abduction 5° and adduction 20°. The wrist is stable and painless. The grip power of the right hand increased to 21 kg. now. X-ray films show the prosthesis in place and no clear zones around the stems and pegs (Fig. 3). He is rehabilitating himself to return to his original work as a carpenter.

Case 2 was a 66 year old female house wife. She had been suffering from rheumatoid arthritis which initiated at the metacarpophalangeal joint of the right thumb at her age 42, and spreaded to other joints. Despite of various medical treatments including gold therapy, deformity



left right

Fig. 3. A postoperative radiograph showing both wrists replaced with prostheses.

of the hand gradually progressed. Since the metacarpophalangeal joints of the right fingers had been severely destroyed and dislocated, they were replaced by silicone-rubber prosthesis in 1980. The right wrist joint was fused next year, since the joint had been palmarly dislocated and unstable. Although the right wrist became stable and powerful, her daily activities were more disturbed because she could not manage such important activities as toiletting after the wrist arthrodesis. Pain and deformity of the left hand further progressed, and she could no longer manage her daily activities. The wrist joint was completely dislocated and unstable. The grip power markedly decreased and was measured only 22 mm Hg by a hemadynamometer. X-ray films revealed the left wrist joint dislocated anteriorly and all metacarpophalangeal joints also anteriorly dislocated (Fig. 4). The patient refused a proposal of arthrodesis of the left wrist, and desired restoration of a mobile wrist. A total prosthetic replacement of the left wrist was undertaken on February 14, 1984, using the SCW prosthesis. After making a S-shaped skin incision on the dorsum of the wrist, the dorsal capsule of the joint was exposed. Two large subcutaneous veins were cut, but not ligated to be anastomosed at the later stage of the operation. The articular cartilage completely vanished away from the wrist joint. The carpus was migrated antero-proximally under the deformed distal radius. The extensor tendons were interposed between the radius and the dislocated carpus. And they were worn off considerably. The carpometacarpal joints were loose and subluxated. The anteriorly slanted distal radius about 2 cm in length was osteotomised

a. anteroposterior radiograph b. lateral radiograph

Fig. 4. Preoperative radiographs of the left hand showing anterior dislocation of the radiocarpal joint.
(a) The anteroposterior radiograph illustrates advanced destruction of the distal radioulnar joint, the radiocarpal joint and metacarpophalangeal joints. The carpometacarpal joints are also involved, but less damaged.
(b) The lateral radiograph illustrates dislocation of the radiocarpal joint with the antero-proximal migration of the carpus. All metacarpalphalangeal joints show anterior dislocation.

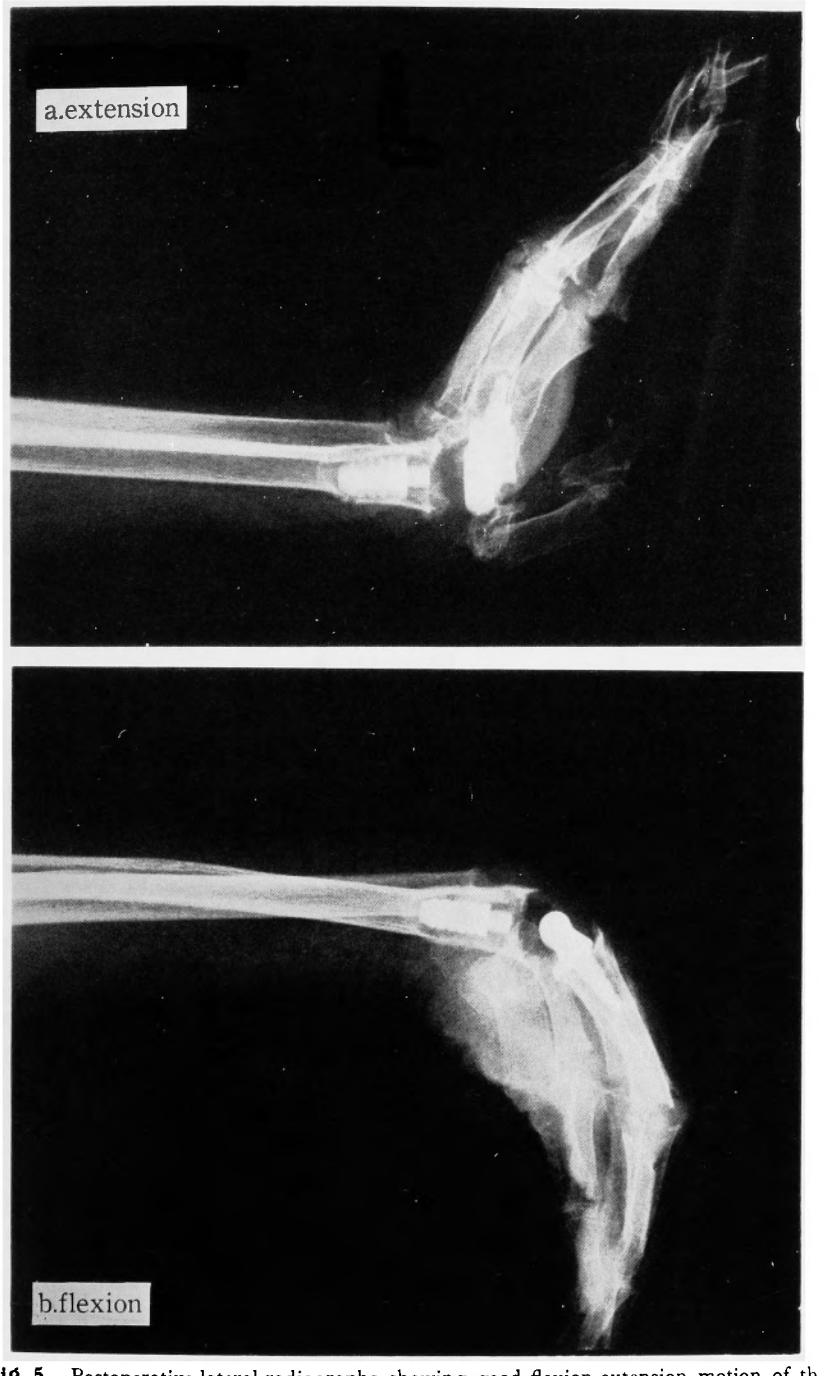


Fig. 5. Postoperative lateral radiographs showing good flexion-extension motion of the wrist. The articular portion of the distal component rotating on the shelf of the proximal component.

and removed to make a transverse cut-surface. The second and third carpometacarpal joints were disarticulated, and almost entire central carpal bones were removed. Then, the SCW prosthesis, which was smaller than that used in case 1, was placed there. The quadrangular ceramic stem of the proximal component was inserted into the distal radius without difficulty. Two pegs of the distal component were inserted into the bases of the second and third metacarpal. Stability of the prosthesis was satisfactory even without cementing. After the prosthesis was placed in the proper position, the dorsal joint capsule was repaired. Veins previously cut were anastomosed under a microscope. The subcutaneous tissue and the skin were closed by layer. After sterile dressings were applied to the wound, the left hand was encased in a short arm plaster cast. Postoperative course was uneventful and active motion exercises were started 3 weeks after the operation with a dynamic brace. Two months later, dislocated metacarpophalangeal joints of all fingers of the left hand was replaced with silicone-rubber prostheses. At present, 1 year and 10 months after the operation, the left wrist is stable and painless. The ranges of passive motion of left wrist are dorsiflextion 65°, palmar flexion 45°, abduction 10° and adduction 30° (Fig, 5). She is very pleased with the postoperative result and manages almost all daily activities with the left hand now.

Discussion

In 1973 *Meuli*[7] first reported a metal wrist prosthesis. *Swanson*[11] reported a silicone-rubber prosthesis for the wrist in 1973. Since then, various metal wrist prosthesis in different designs were reported by *Volz*[14,15], *Beckenbaugh* and *Linscheid*[1], and others[2,6,12]. *Sadahiro*[10] and *Moritani*[9] independently reported different wrist prosthesis made of ceramics in 1982. Those prostheses had different designs and structure. A "ball-and-socket type" prosthesis could provide good mobility, but often feiled to provide good stability due to inbalance of muscles around the wrist joint. Since a ball-and-socket type prosthesis has only one center of rotation, the excessive ulnar deviation of the wrist often occurs postoperatively because of the stronger ulnar forces. To avoid the postoperative ulnar deviation, *Hamas*[5] and *Sadahiro*[10] adopted a wrist prosthesis with a precentered axis to balance the muscle power around the wrist. *Beckenbaugh*[3] made an unconstrained wrist prosthesis named "Convex Concave Carpal Prosthesis" which had two rotational axis.

The SCW prosthesis reported here is an unconstrained wrist prosthesis which is made of high density polyethylene and alumina ceramics. The stem and pegs of the prosthesis are made of alumina ceramics which incorporate to the bone well without cementing. As the articular surface of the proximal component is made of high density polyethylene, minimum friction occurs to the motion of the articular ceramic surface of the distal component. The palmar shelf protruding from the proximal prosthesis not only prevents the palmar dislocation of the distal component, but also structurely allows full extension of the wrist joint. Full extension of the wrist joint is very important to protect the patient from serious injuries on a fall. Owing to the wide contact area of the articulation between the proximal and distal component, the wrist is very stable postoperatively. It is well known that the function of the hand is well preserved, even if

the wrist has no motion but stable, as examplified by a wrist after arthrodesis[8,13]. On the contrary, even a mobile hand has little function due to loss of power, if the wrist is very unstable, as examplified by a dislocated wrist joint in rheumatoid arthritis. The SCW prosthesis can provide good mobility and excellent stability. Besides, the prosthetic replacement eliminates pain, and gives strong power to the wrist. This prosthesis was clinically used only for two cases, and the follow-up periods are still short. However, it is noteworthy that both patients are pleased with the postoperative results, and that prosthetic replacement restored better function of the hand than arthrodesis in case 2. When the results of the first and second cases are compared, it is noticeable that the range of mations of the second case is much greater than that of the first case. It is probable that the following factors influenced the results. Firstly, the anterior capsule was preserved in the first case, whereas it was removed in the second case. As the result, a greater range of motion was obtained during the operation and maintained postoperatively in the second case. Removal of the anterior capsule of the wrist joint did not produce instability, but rather resulted in good mobility. Secondly, the period of immobilization had to be postponed to 5 weeks postoperatively in the first case, while the active wrist motion was begun 3 weeks after the operation in the second case. The early motion exercise seems a very important factor influencing the postopetative range of motion of the wrist.

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和文抄録

安定型セメントレス人工手関節
（SCW 型人工関節）

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上羽 康夫，西島 直城，辻 丈夫，浜西 千秋，山室 隆夫

可動性と共に安定性を重視した新らしい型の人工手関節を報告した．この人工関節は2つの部分より成るが，関節面は前後面には強い彎曲，橈尺面には緩い彎曲を形成しているので屈曲・伸展運動域は大きく，橈屈・尺屈運動域は小さい．したがって，ボール・アンド・ソケット様式の人工関節でよく起る橈屈変形はこの型では起らない．2つの部分が接する関節面は広いので，安定性がある．骨内に挿入する部分はアルミナ・セラミックスでできており，骨セメントなしでも骨との接合は十分に得られる．

この人工手関節は2症例に用いられた．症例1は38才の男性大工であり，変形性関節症により破壊された右手関節の全置換術に用いられた．症例2は66才の女性であり，慢性関節リウマチにより高度に破壊され，前方脱臼した左手関節の全置換術に用いられた．

術後成績は両症例ともに無痛で安定性のある手関節機能が得られている．